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A REGIONAL LAND USE SURVEY BASED ON REMOTE SENSING AND OTHER DATA

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QUARTERLY REPORT FOR PERIOD APRIL 10 - JULY 10, 1976

Prepared for
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Report reflects joint work of Federation, six state participants, and Colorado State University.

16. Abstract

During this quarter a review meeting was held in Denver on June 7, 1976. LANDSAT classified land use/cover maps have been produced and distributed to member states by the subcontractor, CSU. States have been conducting verification field work to determine the accuracy of the satellite imagery. Also, states prepared sets of other data for compositing with LANDSAT output, via computer cellular processes, for purposes of more sensitive definition, optimal or restrictive location of activities. Los Alamos Scientific Laboratories has been cellularizing this data from coded grids from the states and from the LANDSAT map tapes.

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PREFACE

Objectives: To test and apply Landsat, other remote sensing and ground data, in an optimum mix for seasonal land use survey, for portions of six states in the region (Montana, Wyoming, Colorado, New Mexico, Utah, Arizona). Specifically: (1) to encourage interstate cooperation in the utilization of earth resources satellite technology for solving land use planning problems; (2) to discuss and work toward the development of compatible interagency, interstate information system procedures; (3) to adopt and test a common land use classification; (4) to evaluate the efficiency of a land use information system, utilizing satellite and other data; and (5) to provide a medium for information exchange concerning remote sensing and geo-information systems.

Scope of Work: This quarter's work, April 10 to July 10, is following the work plan of January, 1975. The schedule and time sequence following page 14 of that work plan are used here as references.

Colorado State University has produced classified land use and cover maps from LANDSAT data for two of the four quadrangles in each state. The state lead agencies have that information and are utilizing it in verification studies. The state lead agencies have collected additional ancillary data to be composited with LANDSAT land use/cover information for relevant multi-source land use analyses. A review meeting of the ad hoc committee on Earth Resources Technology Applications and the LANDSAT participants, plus other interested persons from the Rocky Mountain region, was held June 7, 1976, in Denver. Additional information on that session is attached. CSU is now working with the states on verification of land use classification/cover maps based on LANDSAT information, and Los Alamos Scientific Laboratories is carrying through the computer mapping for multi-map compositing and analysis of inputs from each state.

Conclusions:

A. LANDSAT maps verification is proceding in each state.
B. Colorado State University and the Federation have completed new software programs for LANDSAT digital processing and for multi-source map compositing.
C. A project review meeting held in June was well attended and produced significant decisions.

INTRODUCTION

This is the fifth quarterly report in the 18-month scheduled project.

The project scope is complex and must be described in parallel roles of six state lead agencies, a technical contractor for extracting land use information from LANDSAT digital tapes, Los Alamos Labs preparation for computer mapping and analysis, and the Federation as coordinator and demonstrator of multi-source and multi-purpose information procedures.

This summary refers to activities scheduled for this period in the work schedule and calendar of the original work plan, January, 1975.

Task II.B - Statistically analyze and characterize land use readings in order to recognize erroneous data and determine clear separations between classes--substantially completed; some work continues.

Task II.C - Analyze effects of extraneous variables, i.e., geology soils, etc., on the interpretation of land use classes--substantially completed; some work continues.

Task II.F - Determination of socio-economic and resource topics for combination with LANDSAT data--now being conducted by state lead agencies.

Task III.D - Collect additional data for LANDSAT verification--now underway in all states.

TASK III.E - Identify land uses in all cells of selected maps--now underway; (See CSU schedule, Main Text).

Task III.H - Convene all participants for a review meeting--held in June; additional meetings scheduled; (see section next reporting interval).

Task IV.B - Examine classification errors - begun using the feedback from state verification field work.

Task IV.F - Produce composite maps, using other data along with LANDSAT - begun, all states.

MAIN TEXT

June 7 Project Review Meeting

DECISIONS

1. The attached milestone calendar was agreed upon, given a two-week leeway for submitting final results on each activity.

2. It was agreed that at the end of June or early part of July, the states would have their composite data ready to submit to Los Alamos and that Utah and Montana would also conduct the same analysis on their own equipment to compare costs and techniques.

3. FRMS will develop specific format guidelines for state, CSU, and Los Alamos final reports.

4. It was agreed that Section III-F of the attached suggested final reporting criteria would be eliminated.

5. It was agreed that CSU would decide upon one of two alternatives for solving their LANDSAT mapping system difficulties and would begin producing final-classified maps in two weeks, with the following quads having first priority: Hedgepath Hills, Arizona; Fox Creek, Colorado; Colestrip, Montana; Santa Fe, New Mexico; Farmington, Utah; Buffalo, Wyoming.

MEETING SUMMARY

1. Multi-source data collection and composite analysis. The status of each state's work on this part of the project was briefly discussed:

   Arizona - just starting; will be completed by the second week of July; will be a land use analysis.
   Colorado - the analysis developed will determine reclamation and rehabilitation potentials; three maps already formatted on the 1:24,000 scale, coded and keypunched. (See attached source map documentation for elevation aspect and slope.)
   Montana - just starting data collection for an energy analysis; will also do parallel analysis in state to compare to Los Alamos.

<u>New Mexico</u> - no represent ve present. (Nez later visited N.Mex.)
<u>Utah</u> - just beginning data collection for land use analysis; will also run in-state to compare with Los Alamos.
<u>Wyoming</u> - collecting data now and coding; will determine analysis scheme by the end of the month.

Forms C1, 2 and 3 for the composite analysis (in the Remote sor 6) were discussed. It was determined that the states have the following tasks to complete with the next few weeks:

a. Determine analysis scheme (form C1).
b. Collect base maps on 1:24,000 scale quad sheet (for the quad designated for the detailed analysis).
c. Code with CMS-II sector sheet; register first cell in upper left-hand corner.
d. Can use up to 25 alpha codes (no 0) and 10 numbers--0 through 9.
e. Assign values of 0 through 9 for interpretations, (Form C3); assign relative map weights; be sure to includ^ LANDSAT land use/cover in analysis, (Form C2).
f. Punch cards in P-card format (see Chapter 4 of CMS-II Users' Manual previously sent).
g. Submit P-card decks (or code sheets in special cases) to FRMS in the following format: each deck should have an identifier card in the front of it with the map topic, name sector number--starting in the upper left corner sector (1,1), adjacent to the right sector (1,2), down and to the left side, sector (2,1)--and in the south-east corner, sector (2,2)--and which half of the sector this card set is--left half or right half.
h. If possible, submit duplicates of each topic map.

After FRMS receives the cards from each state, they will be submitted to Los Alamos, along with the land use/cover tapes from CSU. Forms C1, 2, 3 will be submitted to Los Alamos. Duplicate maps, if available, will be submitted to Los Alamos. They will run a computer edit on the P-cards and correct technical errors. They will then produce a map and re-submit to states for review and any final corrections on data. States will return corrected maps to Los Alamos, who in turn will run the composite analysis.

2. <u>Final Reporting procedures</u>. The group reviewed and discussed the suggested criteria (attached), Section III being relevant to the states. The parts of each state's final report will include a section on the LANDSAT activities and data (see outline Sections A, B, C); a section on the multi-source data analysis and compositing (Section D & E); a section on related activities and spinoffs (Section G); and a detailed accounting statement as outlined in the initial contract. FRMS will produce a detailed format guideline to be sent to the states soon.

Verification of LANDSAT Classified Land Use/Cover Maps. States are trying various procedures for verification in a wide variety of natural resource areas, crop areas and urban areas. FRMS provided initial Verification forms and a random sample location overlay (please refer to previous Quarterly Report). Now the states are using field and office data in several ways to accomplish this verification. The questions are: (a) adequate field information on sample plots, including significant variations in slope, aspect, crown density of trees, and (b) an adequate numbrt of samples in each original class.

Utah had gathered ground truth on many sample plots during the first round of defining LANDSAT training sites, and all this information is providing a good statistical basis for verifying the LANDSAT maps. Other states are finding that the accomplishment of statistically sufficient verification field work is difficult and two years removed from the actual dates of LANDSAT imagery.

Arizona and New Mexico are using much available aircraft imagery and conventional data to verify already well-known targets and then move into other land uses and cover types, new field information as necessary.

The step-wise procedure of Arizona would first compare known land use and cover with the new LANDSAT classification, and if a high percent of accuracy is indicated, there would be no need to check the aspect, slope, and crown density of the verification plots. However, where the LANDSAT map seems erroneous, the aspect, slope and crown density would be checked as these conditions may account for the LANDSAT error.

Some verification problems are arising due to the inclusion of "activity" categories such as "golf courses" or "commercial areas" which require additional zoning or engineering type information beside the purely spectral information in LANDSAT imagery - pointing to the need for a compositing process outside the LMS program.

State teams may recall the early project discussions in connection with selecting the first 19 categories shown below. Various conventional "land uses" were recognized as "activities" involving much more description than spectral reflectance from soil, vegetation, pavement, roofs or ratios thereof; also human utilization-commercial, industrial, residential, recreational, etc. Most of these complex categories require a cellular compositing procedure which could accept economic, land valuation, census, engineering geology data, or "blueprints" such as proposed subdivisions, unbuilt zoning, etc. in addition to LANDSAT spectral signatures.

This is one of the reasons for "external compositing," using LANDSAT cellular inputs together with other gridded data. It is interesting to note that Colorado is using this approach to define a Vegetation Index which is sensitive to many factors (see Colorado compositing case below).

From the standpoint of testing LANDSAT ..uity under the new LMS program of CSU, some of these detailed subcategories are useful and may lead to better aggregation of basic LANDSAT categories. This "overlap" is, of course, important for determining the most appropriate use of LANDSAT data and the most efficient way to mix it with conventional data.

This is precisely the type of finding which is sought in the State Verification reports.

The state teams are, of course completely on their own statistical basis in obtaining the verification data. The V-2 forms, as first issued, provide for a step-wise verification via 3 blocks of data for each 10-acre plot: (1) land use/cover, (2) aspect and slope, (3) crown density of trees and brush, and then final checking against (4) LANDSAT classification of the 1.1 acre subdivisions of the 10-acre plots.

State Map Compositing Formulations. All states are preparing other data in addition to the LANDSAT categories, for reduction to cellular, digital form, for compositing. They are using one of their four-state quads as a compositing area, and a typical land use/management problem as the compositing objective.

WYOMING

Compositing objective: Physical limitaticns of urban growth in the Buffalo Quadrangle.

Component Source Maps: Soils, slopes, flood hazard, land ownership, potential minerals and LANDSAT land use/cover categories divided into Restrictive and Non-Restrictive categories. All these maps are converted into cellular, digital, ordinal form, and differential weights are imposed on the maps to reflect the compositing objective.

NEW MEXICO

Compositing objective: Area restrictions against urban development in the Santa Fe Quadrangle.

Source Maps: Soils, slope depth to ground water, population density, and selected restrictive land uses and vegetation (from the LANDSAT map).

UTAH

Compositing objective: Constraint tc non-agricultural development in the Farmington Quadrangle.

Source Maps: Slope, soil, land value, transportation accessibility, zoning, selected land uses and vegetation from LANDSAT and other sources.

ARIZONA

Compositing Objective: Restrictions on urban development in the Hedgepeth Quadrangle.

Source Map: Slope, floodable land, topography, land owndership, land uses and vegetation selected from LANDSAT map.

COLORADO

Compositing Objective: A multi-source revegetation index in the Fox Creek Quadrangle.

Source Maps: Soils, slopes, aspect angle, elevation, and selected vegetation categories from the LANDSAT map.

This composite demonstration uses areas of known past land clearance and clear cutting and numerous variables relevant to revegetation. These variables will be analyzed together through cellular mapping for evaluating the level of approach to climax natural vegetation. This will assess the possibilities of using LANDSAT imagery more extensively for this purpose.

MONTANA

Compositing Objective: Coal strip mining and land reclamation feasibility in the Colstrip S.E. Quadrangle.

Source Maps: Presence of coal seam, depth of overburden, depth to ground water, restrictive land uses and vegetation derived from the LANDSAT map.

NEW TECHNOLOGY

For the past year, the Federation has been involved in a project parallel to the LANDSAT effort: the development of a new computer composite mapping system (CMS-II). That system and technical and user documentation have been completed and are being presently delivered to many users across the country. Requestors have thus far included local governments, state governments, federal agencies and universities.

CMS-II or a similar mapping system will be utilized at Los Alamos Laboratores for combining LANDSAT classified data with other multi-source information for specific land use planning problems. The Composite Mapping System-II has been designed to handle a variety of inputs, including conventional maps and aerial photos, reformatted LANDSAT tapes, point-polygon digitized tapes, socio-economic data on tapes and in tabular form and point sample data. The CMS-II system also allows for a variety of analyses, including interpretation of topic maps, weighting or assigning of values to data compositing numerous maps, providing statistical tables and histograms, accessing standard statistical packages to conduct multi-variate analyses on cellular maps, etc.

CMS-II is a cellular computer mapping program for compiling and analyzing natural resources and socio-economic data by public and private planners. Applications have included the production of maps showing the degree of environmental limitations to development, optimal locations for various industries, areas of greatest need for social services, areas of land use conflicts, statistical explanations of geographic related activities, and so on.

A further technical description and information on obtaining CMS-II is included in a Regional Technical Advisory in Appendix II of this report.

Concerning the innovative program for processing the digital tapes--tne new LANDSAT Mapping System (LMS)--the Colorado State University contractor has gone through substantial adaptations. As reported in the previous Quarterly Report, there are great advantages in handling simultaneously many variables and doing it for any selected window area of a LANDSAT scene. However, some of the problems which have been found and mostly resolved are as follows.

The multidate approach selected for this project has created many problems from which we have learned a great deal. The problems have basically been:

(1) Many difficulties were encountered in manipulating the data for the three or four dates involved in each state and in maintaining registration for the three dates. This has been primarily a problem which has resulted in delays in completion of this effort.

(2) The classifications results have a tremendous potential but at the same time, the multidate data is extremely demanding on the selection and processing of training data. Processes which were very good for single date data have proven to be inadequate for multidate data. Primarily the difficulties arise from the sensitive discrimination ability of multidate data, which makes possible discrimination between third and fourth level land use categores. It also is possible, however, that the data and signatures may relate to a specific training field and not a land use or vegetation category. In other words, the method is so sensitive that the signatures may become too specific and not sufficiently general for land use map preparation. This has resulted in much extra work in the preparation of training data and manipulation of the signatures to make them representative of a class and not a specific location.

PROGRAM ON NEXT REPORTING INTERVAL

General activities during the next quarter, July 10 - October 10, will involve verification of LANDSAT land use/cover classification maps, multi-source data compositing, and completion of final reports by states, subcontractor and contractor. Specific activities proposed for the next few months include:

(1) completion of verification of LANDSAT data by the state lead agencies,
(2) final production of LANDSAT land use/cover maps by Colorado State University--acoording to the previously announced schedule,
(3) completion of multi-source data mapping in cellular format by state agencies with computer compositing with LANDSAT information by Los Alamos,
(4) Los Alamos Laboratories will complete composite mapping analyses according to state guidelines,
(5) a meeting of project participants is scheduled for September 13, 14 to review activities to date, LANDSAT products and to submit draft final reports.

CONCLUSIONS

A. Procedures have been developed for LANDSAT verification and for multi-source map compositing. The state lead agencies are now working on these data collections.

B. Colorado State University and the Federation have completed new software programs for analyzing multi-source and LANDSAT digital information.

C. A project review meeting held in June was well attended and produced significant decisions.

RECOMMENDATIONS

It is recommended that this project be extended for an additional three months - October 7, 1976 to January 7, 1977 - for the purpose of adequately evaluating and reporting on the six-state experience and on the CCT processing innovation developed in this project.

Although it is possible to achieve the essential substance of a six-state report on or shortly after the October final reporting date, the richness of the project experience would justify a continuation. More particularly, the following work could be accomplished in the additional three months:

A. The states would have more opportunity to sound out their own agencies, which would have time to absorb the material and respond on the practicability of applying LANDSAT plus source data in a working system. By mid-October, the material evidence would only become available. It should be noted that all of the states were set back by two or more months in mid-1975 due to the delay in receiving color infrared over-flight data and one was set back longer due to its unusable quality.

B. Colorado State University developed a new LANDSAT Mapping System (LMS) program, for efficient/multi-spectral analysis, ability to handle other ground truth variables, and ability to handle multi-date LANDSAT scenes. This new program should be adequately outlined for the information of NASA and other users, but this is not possible by October 7. It may be recalled that the original project proposal of July, 1973, requested some $212,000 for multi-spectral processing and this would use the original pattern recognition program (RECOG) which has been developed by Colorado State University in grassland applications. But the new economy budget of this project, beginning in April 1975, reduced this fund by 58%. At this point, the new LMS program is not written up in manual form and is not transportable. It needs a program outline of three components in order to be communicated and evaluated by any potential users:

   1. theory and concepts of the new porgram,
   2. outline of operational users manual, and
   3. outline of programmers manual covering all subroutines.

C. In the additional time requested, the Federation would be able to provide much more complete report consolidation from the six-state components, including the Colorado State University component and Los Alamos Scientific Laboratories component. This great variety of material deserves comparison and evaluation in a regional report. In addition to questions of remote sensing technical efficiency, there are questions of collaboration, adoption of interstate land use classification, interchange or sharing of work in common interstate resource areas, etc.

D. Further, the Federation would be able to address the possibilities of applying the new process to common interstate problems. This was the premise of the original proposal for the use of LANDSAT and other data in July, 1973. At that time, the pending federal legislation on land use planning would have activated state and federal agency planning for "critical land and water use areas." Since that time, additional issues of coal strip mining, coal gasification, thermo-electric plant development, pipeline construction, water diversion and land reclamation have confronted the states and federal agencies, and the need for some centralization or commonality of resource data and analytic services has become more serious. This current LANDSAT and related data demonstration is timely. In three additional months, the Federation could sound out the various state and federal agencies and outline appropriate applications of this technique.

It will be recalled that the original proposal of the Federation for this project, submitted in 1973, would have engaged seven professionals part-time over a thirty-month period (in the Federation) plus the six-state teams, plus Colorado State University. The technical work which has been accomplished in this actual project is similar, but the quantity is so extremely abbreviated as to be in danger of being overlooked. It has been possible only to fund two Federation technicians part-time, and to allocate less than half of the originally proposed budget for the state teams and for the CCT processing subcontract. It is only by the good grace of Los Alamos Scientific Lab that four of the states are receiving composite mapping machine service.

As mentioned above, a further shortfall in this project has been the delay of several months experienced by the states in receiving their aircraft CIR imagery from NASA, during the critical ground truth season in mid-1975.

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Federation of
Rocky Mountain States, Inc.

THE REMOTE SENSOR 7

Distributed by the Federation for persons interested in the Remote Sensing Project. Utah Governor Calvin L Rampton is chairman of the Federation; Jack M. Campbell is president; Dr. Philip Burgess is executive vice president. Dr. Keith Turner is chairman of the Committee on Earth Resources Technology.

NEXT PROJECT MEETING SEPT. 13-14

This meeting of the Earth Resources Technology Committee will review the completion of LANDSAT mapping, verification and compositing using additional data in each State, and the draft final reports of the States and CSU. More particularly, the agenda of the meeting will cover:

- The verification of LANDSAT mapping - results of field and office work by the States, discussion of principal technical problems.
- Compositing of other sources of data with LANDSAT by means of cellular procedure, for better definition of "activity" areas, restrictive or optimal areas, etc.
- Los Alamos Scientific Laboratory - special observations on the cellular processing, etc.
- Final reports of the States and CSU - discussion of drafts and common conclusions for the Federation.
- Completion calendar needed for project finalizing report, essential circulation and clearance in States, possible follow-up activities with NASA for further applications of the system.
- Business matters before the Committee.

GUIDELINES AND FORMAT FOR FINAL REPORTS

States, CSU and LASL are scheduled to draft their final reports in September. The Federation offers the attached final report outline which blends together the NASA format with the outline which the Committee has had under consideration for the past year. The new format is attached to this newsletter. It forms a checklist on this multi-purpose project.

Also a general scope outline of the Colorado State University report is appended, for information of the States in formulating their reports - essentially to avoid their attempt to cover material which CSU will elaborate.

The possible scope of the Los Alamos Scientific Laboratory remains open for any description on the mass processing of cellular maps, for four of the States, plus comments on new scientific possibilities in digitizing, applications to geologic and energy studies, etc.

In order to cover all necessary material in 1½ days, all States are asked to Xerox 15 copies of their report drafts for exchange with other members at the meeting. This will save much oral time and note-taking, and let the meeting focus on common questions.

WHICH OF THE TWO VERSIONS OF LANDSAT MAP IS BETTER FOR VERIFICATION?

Two versions of the LANDSAT maps have been issued for the test quadrangles, one having a "classification threshold" of ten percent and the other zero or one percent. The maps have a footnote #4 defining "classification threshold." Nevertheless, questions have arisen from the States concerning which map is best for the verification. A further explanation from Dr. Maxwell is as follows:

The zero or one percent classification threshold map is recommended for verification work, because the computer program makes this map by classifying every pixel according to its highest possibility of falling into one category or another. By comparison the ten percent classification threshold screens out non-legitimate classes or heterogeneous indicators, and produces blanks in some locations. These differences between the maps may be further discussed at the meeting.

LANDSAT VERIFICATION UNDERWAY

States are finding various problems and procedures for field verification. Utah had gathered ground tru on many sample plots during the first round of defining LANDSAT training sites, and all this information is providing a good statistical basis for verifying the LANDSAT maps. Other states are finding that the accomplishment of statistically sufficient verification field work is difficult and two years removed from the actual dates of LANDSAT imagery.

Arizona and New Mexico are using much available aircraft imagery and conventional data to verify already well-known targets and then move into other land uses and cover types, new field information as necessary.

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Some verification problems are arising due to the inclusion of "activity" categories such as "golf courses" or "commercial areas" which require additional zoning or engineering type information beside the purely spectral information in LANDSAT imagery - pointing to the need for a compositing process outside the LMS program.

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This is one of the reasons for "external compositing," using LANDSAT cellular inputs together with other gridded data. It is interesting to note that Colorado is using this approach to define a Vegetation Index which is sensitive to many factors (see Colorado compositing case below).

From the standpoint of testing LANDSAT acuity under the new LMS program of CSU, some of these detailed subcategories are useful and may lead to better aggregation of basic LANDSAT categories. This "overlap," is of course important for determining the most appropriate use of LANDSAT data and the most efficient way to mix it with conventional data.

This is precisely the type of finding which is sought in the State Verification reports.

The state teams are, of course, completely on their own statistical basis in obtaining the verification data. The V-2 forms, as first issued provide for a step-wise verification via 3 blocks of data for each 10-acre plot: (1) land use/cover, (2) aspect and slope, (3) crown density of trees and brush, and then final checking against (4) LANDSAT classification of the 1.1 acre subdivisions of the 10 acre plots.

BOX SCORE ON COMPOSITING

At this writing, all States are substantially into compositing and some have completed their work and sent the grids and/or punch cards to the Federation for processing by LASL. Dr. Keith Turner has been consulting with LASL to execute the cellular mapping of all maps other than LANDSAT and to run composite maps including selected categories from LANDSAT map tapes. Wyoming, New Mexico and Colorado work are now in this process. Utah and Montana are cell-mapping new topics and compositing their own work. Arizona is preparing its grid punch cards for additional maps for compositing. In order to get the LANDSAT data automatically into the composites CSU has supplied the LANDSAT mapping tapes to LASL and to Utah. Montana may obtain its LANDSAT mapping tape whenever it is ready.

WYOMING

Compositing objective: Physical Limitations of Urban Growth in the Buffalo Quadrangle.

Component Source Maps: Soils, Slopes, Flood Hazard, Land Ownership, Potential Minerals and LANDSAT land use and cover categories divided into Restrictive and Non-restrictive categories. All these maps are converted into cellular, digital, ordinal form, and differential weights are imposed on the maps to reflect the compositing objective.

NEW MEXICO

Compositing objective: Area Restrictions Against Urban Development in the Santa Fe Quadrangle.

Source Maps: Soils, Slope, Depth to Ground Water, Population Density, and selected Restrictive Land Uses and Vegetation (from the LANDSAT map).

UTAH

Compositing objective: Constraint to Non-agricultural Development in the Farmington Quadrangle.

Source Maps: Slope, Soil, Land Value, Transportation Accessibility, Zoning, selected land uses and vegetation from LANDSAT and other sources.

ARIZONA

Compositing Objective: Restrictions on Urban Development in the Hedgepeth Quadrangle.

Source Map: Slope, Floodable land, Topography, Land Ownership land uses and vegetation selected from LANDSAT map.

COLORADO

Compositing Objective: A Multi-Source Revegetation Index in the Fox Creek quadrangle.

Source Maps: Soils, Slopes, Aspect Angle, Elevation, and Selected Vegetation categories from the LANDSAT map.

This composite demonstration uses areas of known past land clearance and clear cutting and numerous variables relevant to revegetation. These variables will be analyzed together through cellular mapping for evaluating the level of approach to climax natural vegetation. This will assess the possibilities of using LANDSAT imagery more extensively for this purpose.

MONTANA

Compositing Objective: Coal Strip Mining and Land Reclamation Feasibility in the Colstrip S.E. Quandrangle.

Source Maps: Presence of Coal Seam, Depth of Overburden, Depth to Ground Water, restrictive Land Uses and Vegetation derived from the LANDSAT map.

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RAMPTON STATES FEDERATION ENDORSEMENT OF LANDSAT FOLLOW-ON PROGRAM

The attached letter was sent by Governor Rampton to Dr. James Fletcher voicing support by the Federation Governors of NASA's LANDSAT follow-on program:

STATE OF UTAH
OFFICE OF THE GOVERNOR
SALT LAKE CITY

CALVIN L. RAMPTON
GOVERNOR

July 7, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters - Code A
Washington, D.C. 20546

Dear Jim:

I am writing to convey the endorsement of the states comprising the Federation of Rocky Mountain States for NASA's proposed LANDSAT follow-on program.

The Federation currently has underway a well-coordinated NASA-funded LANDSAT project using a digital satellite and ground-source data to conduct land use analysis. This new approach to acquiring and analyzing land use data provides planners in the region an inexpensive and objective source of da a for developing a regional land use inventory.

The proposed capabilities of the LANDSAT follow-on program would provide additional benefits through increased amounts of information supplied in more varied and usable form and on a continuing basis. The vast expanses of this Rocky Mountain Region unquestionably lend [illegible] to the use of remote sensing techology. The resolution of new problems facing this region as a result of the energy onslaught in the Rocky Mountain states requires the application of LANDSAT and its associated technologies.

Therefore, I am authorized by my colleagues in the Federation to indicate our desire to see the LANDSAT follow-on become a perma[illegible] of the federal government's data collection efforts. [illegible] allow our states [illegible] to continually utilize this information as a part of our planning and policy making process.

You will be pleased to know that our regions assessment of the LANDSAT program as one of the most significant achievements of the U.S. space program is concurred in by the National Governors' Conference which earlier this month adopted the enclosed resolution at our annual meeting.

Sincerely,

Governor

Enclosure

ORIGINAL PAGE IS
OF POOR QUALITY

GUIDELINES AND FORMAT FOR STATE REPORTS

(This form is based partly on NASA reporting format and partly on the outline developed in the January and June meetings)

FINAL PROJECT REPORT FOR ____________________
(State Name)

Participation in a Rocky Mountain Regional Project--Applications of Remote Sensing and Other Data For Composite Analysis in Land Use and Natural Resources Decision-Making.

Prepared by: ____________________
(Lead Agency Name)

____
(Lead Agency Representative)

____
(Address)

____

____
(Phone)

____
(Date of Report)

Prepared for: The Federation of Rocky Mountain States

NASA PROJECT

#NAS5-22338

This is a report by one of the project participants and does not necessarily reflect the views of the National Aeronautics and Space Administration.

CONTENTS

(List of headings, sub-headings, appendices, etc.)

ABSTRACT

(Brief abstract of work accomplished, special problems, significant results, etc. One-half page maximum.)

MAIN TEXT

(Suggestions: Include in each section an adequate narrative statement, plus photographs, maps, diagrams and other relevant supporting data, as needed. The narrative should point out any significant problems and difficulties, as well as successful accomplishments and provide a clear discussion of project procedures and history. Style instructions: single space, block style, please use the decimal numbering shown below for interstate comparability.)

1.0 THE PROJECT AREAS

1.1 Locate on a small map, reduced USGS or other, the four or more quadrangles, with extra heavy line around the principal test quadrangle.

1.2 Describe the physical and economic characteristics, reasons for selecting, typical or problematic land/water uses, etc.

1.3 Discuss the relevant issues of planning, control, etc. in the test quadrangle (as a basis for later discussion of the LANDSAT verification, and for the compositing rationale).

2.0 LAND USE/COVER CLASSIFICATION (What, Why and When)

2.1 Reasons for selection of the categories, relation to other state data, USGS recommended classifications, etc. Relate to 1.2 above.

2.2 Adequacy of details from LANDSAT, comments on verification, resolution, etc.

2.3 Usefulness of supplementary data in addition to LANDSAT input for improving the classification or the problem analysis (via compositing).

2.4 Comments on the difference between functional activity classifications and the remote sensing visible classifications. Wherever this occurs it is important to define the combination of LANDSAT and supplemental data, via a compositing procedure.

3.0 LANDSAT DATA UTILIZATION

3.1 Ground truth for signature calibration of the digital LANDSAT tape.

3.1.1 Procedures and problems in selecting ground truth sites and collecting relevant data; typical location map and coding of data, etc.; usefulness of color infrared and black and white air photos, etc.

3.1.2 Summary of man-time for field work, plus inter-office data collection. Reduce this to some area/unit averages.

3.1.3 Need for standardized ground truth procedures--questions which arose in locating and collecting ground truth--indicate the kind of instructions which would be useful in a future manual for ground truth work.

3.2 Verification procedure for determining accuracy of LANDSAT maps.

3.2.1 Procedure used in verification. This section may be organized under headings of: (1) The "V" forms, usefulness and suggested changes; (2) problems and methods in verifying land uses/cover existing two years previously; (3) coping with the seasonal questions as LANDSAT covered several seasons.

3.2.2 Comments on distributing the verification plots; adequacy of sample; significant foot-notes contained in the V-2 Form.

3.2.3 Insert the completed V-1 list of your land use classes and percent accuracy (results) of LANDSAT for each class.

3.3. Comments on LANDSAT compared with other survey methods.

3.3.1 Various methods of current land use identification approaching a resolution of 1 acre. Comments on cost, availability, frequency, and accuracy. (Possibly a table comparing their characteristic with LANDSAT.)

3.3.1 Discuss the practical problems and cost; per quad of the LANDSAT process, including ground truth and verification plus the lab processing cost per quad, which is given by CSU. Discuss the possibile extension of these costs over a larger area, on a production basis, for annual or seasonal coverage by the state. Consider the main technical pros and cons, regardless of possible administrative unreadiness.

4.0 MULTI-SOURCE COMPOSITING (LANDSAT PLUS OTHER DATA)

4.1 Composite map analysis.

4.1.1 Discussion of the pros and cons of a cellular approach, for registering conventional data with the LANDSAT digital cellular maps.

4.1.2 Discussion of your compositing approach in the test quadrangle, i.e., (1) multi-factor definition of a vegetation-soil-slope-aspect syndrome such as Colorado's approach or (2) defining "capability area" made up of various positive and restrictive factors such as "Potential Urban Areas" used by several states, or (3) feasible mining-reclamation areas such as Montana's approach. (You may use Forms C-1, C-2, and C-3 to define these relationships for your state.)

4.1.3 Comments on selection and collection of other data, and maps, (beside LANDSAT) and any problems of converting into cellular form; reformulating data scale for purposes of compositing, etc.

4.1.4 Notes on the program of computer compositing; by state's own process or by assistance of Los Alamos Scientific Laboratory.

4.2 Potential role of other agencies.

4.2.1 Other agency participation and interests in the project in the areas of resource management, planning, etc.: If not now actively engaged in this project, indicate their possible future role. If significant, mention industry groups, such as mining, agriculture, etc.

4.2.2 Possibility of a mapping bank to offer up-to-date LANDSAT plus related physical, social, economic data.

4.2.3 Notes on availability, quality and frequency of input data from other agencies.

5.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.1 Recommendations to the state in general or to any agencies concerned with wide area continuous information, analysis, use of LANDSAT data future efforts, etc.

5.1.1 Summarize costs and relative efficiency in the project areas in terms of average costs per unit area; compare efficiency of this process in terms of update frequency, resolution, etc. with previous practice.

5.1.2 Identify the administrative prospects of establishing/ continuing possibilities of upgrading these methods by means of a multi-source mapping bank. Are certain parts of the state more urgent, where resource development, critical environmental areas as infrastructure decisions are needed?

5.2 Recommendations for interstate collaboration;

5.2.1 Possibilities of adopting common first or second order land use/cover categories for use of LANDSAT mapping banks, over wide areas, watersheds, mineral zones, wildlife habitat, etc.

6.0 RELATED PROJECT ACTIVITIES

6.1 List and include any abstracts of reports, papers, articles etc. (unpublished and published) connected with this project by any member agencies or staff members of the project. (NASA is particularly interested in these spin-offs and relationships.)

7.0 ACCOUNTING STATEMENT

7.1 As per state=FRMS contracts, not to exceed ($10,500 (unless you wish to indicate state dollar or in-kind contributions).

PERSONNEL	COSTS
LAR	
Staff	
Overhead	
TRAVEL	
Test Sites	
Meetings and Conferences	
EXPENDABLES	
Maps, materials, etc.	
OTHER (Please itemize)	________
TOTAL	________

8.0 APPENDICES - As desired reports, maps, etc.

These need not necessarily be reduced to a form for printing and general distribution with the total report. Consider here mainly the limited distribution within your state.

SUGGESTED SCOPE OF CSU REPORT

This part is the technical base (describing LMS, etc.) which is essential to the state portions (on ground truth and compositing, etc.). Following is a preliminary outline, mainly to show the states what will be covered. CSU may elaborate in any direction.

1.0 Reasons for Initial Selection of Areas and Land Use/Cover Categories

1.1 Background of CSU experience with LANDSAT digital applications to certain types of land use/cover.

1.2 Initial selection of 19 categories, expected improvements in discrimination via sub-categories.

1.3 Selection of multi-date LANDSAT scenes relevant to the quadrangle area resources, crops, climates, other land cover, etc.

1.4 Objectives and methods in establishing 1.15 acre cellular grid, relationship to standard 1:24:000 quadrangle maps and other data for compositing, etc.

2.0 Training Site Work - Critical to LANDSAT Signature Calibration

2.1 Significant variables affecting multi-spectral signature analysis, etc.

2.2 Comments on sampling methods, statistical problems of adequate sampling, methods of coding map areas and tabulating ground truth, what variables included, needed.

2.3 CSU field work performed on Colorado sites in this project.

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3.0 Evaluation of New LMS Program

3.1 General comparison of LMS features with previous RECOG (and other) programs, etc.

3.2 LMS special characteristics, efficiencies. Problems of getting adequate variables. Use of sub-categories to improve 1st and 2nd level categories.

3.3 Appropriate role of external data compositing for desired conventional land use "activities," where locations are relatively will known, without seasonal variation

3.4 Summary of applicability: Appropriate categories; frequencies; costs of operational mapping, etc.

3.5 Recommended follow-on work: Documentation of LMS; development of Grount Truth and Verification Manual,; etc.

4.0 Training Benefits of this Project

4.1 R&D activities within CSU. Faculty and student participation in project. Innovations for LANDSAT program. Etc.

4.2 Interstate technical participation, meetings and main interactions with other state teams during this project. CCT orientation received by state teams. CSU - State interactions. Main meetings, reports, papers, etc.